The National Fire and Fire Surrogate Study – Eearly Results and Future Challenges

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The National Fire and Fire Surrogate (NFFS) Study is a study established to compare ecological and economic impacts of prescribed fire and mechanical fuel-reduction treatments. Researchers at 13 independent study sites across the United States use identical treatment and measurement protocols for numerous variables including: vegetation, fuels, fire behavior, wildlife, incidence of diseases and insects, soil fertility and structure, and nutrient cycling. Tom Waldrop and Ken Outcalt, unit scientists, serve as principal investigators for four study sites including a hardwood site in the Southern Appalachian Mountains of North Carolina, a pine-hardwood site in the Piedmont of South Carolina, a site dominated by longleaf pine in Alabama, and a site dominated by slash pine in Florida. Fuel-reduction treatments vary somewhat across the network of sites but all have some form of prescribed burning, mechanical fuel reduction, and burning plus mechanical reduction. Treatments were installed on the SC and FL sites during 2001 and 2002 and the AL and NC were established a year later. Post-treatment changes continue to be measured annually.

Initial results show numerous effects in each ecosystem. Using the Piedmont site as an example, fuel-reduction treatments changed vegetative structure and composition. Burn-only plots had similar composition to controls but fewer trees. Thinning and thinning + burning created distinctly different communities; the thin + burn was the only treatment that increased grasses and forbs. All treatments reduced litter but thinning increased fine woody fuels. Post-treatment fire behavior predicted by the BEHAVE model, indicated that wildfires would be more difficult

to control after thinning until logging slash begins to decompose. Thinning increased bulk density of the surface soil layer. In the O horizon, both thinning and burning reduced total C and N. In the A/Bt horizon, burning reduced total C and N. Thinning and burning together reduced C and N below burning alone. Thinning had a positive effect on herpetofaunal abundance but too few small mammals were captured for statistical analysis. Spring counts of songbird abundance and richness found no differences among treatments. Nest starts were increased one season after all fuel-reduction treatments. The number and size of beetle-killed spots were larger the year after treatment. However, there were no significant differences among treatments. Leptographium incidence was reduced in all post-treatment areas including controls. However, incidence was apparently reduced by fuel reduction. Diseases caused by Phytophthora were increased by thinning and burning alone but decreased by the combination of thinning and burning.

Site locations for the National Fire and Fire Surrogate Study

The results from the numerous individual studies at each of the 13 NFFS sites will be used to advance our knowledge of multiple ecosystem components, but the greater challenge will be to determine if fuel treatments create entirely different ecosystems and if these systems continue to function differently over time. Analyses of ecosystem-level questions are complex because they are interdisciplinary; variables may impact other variables in previously unknown ways. An example of this complexity is the change to the forest floor. Each treatment produced a different forest floor structure: burning removes the litter layer in a relatively uniform fashion throughout the treatment area; thinning,

however, completely removes the litter and duff in some areas but leaves other areas undisturbed. The combination of thinning and burning created the greatest disturbance of all treatments. The effects are more complex than simple differences in forest floor structure. The forest floor impacts numerous variables such as nutrient cycling, decomposition, and herpetofaunal abundance. Each of these variables, in turn, impacts many other variables. The pathways in this simple example are complex and represent only one potential analysis at one study site. Similar pathways must be investigated for all disciplines at each NFFS site and for all NFFS sites combined. Such analyses will be conducted by NFFS cooperators using a number of univariate and multivariate tools for individual study sites and multiple study sites.

Prescribed burning and fire-surrogate treatments created different stand structure and vegetative species composition on the Southeastern Piedmont NFFS site.

t the site level, analyses have been conducted primarily with models using univariate approaches. This approach is useful to answer questions such as how alternative fuel reduction treatments influence plant species diversity or how fire-only and mechanical + fire treatments compare with respect to fuel reduction. The NFFS study is also a multivariate experiment where we have attempted to capture whole-system responses to fuel-reduction treatments. For example, standard multivariate techniques such as ordination and classification can help us understand how treatments influence plant species composition, rather than just diversity as a single metric. Compositional changes are likely to be more important than diversity changes because species differ with respect to their function (e.g. nitrogen fixers), or with respect to their relative value for humans (e.g. native plants vs. invasive plants). We will use a more complex tool, structural equation modeling (SEM), to evaluate how relationships among components within a system respond to treatment. A typical SEM model has a flexible structure of relationships. The investigator builds a hypothetical model that includes the key variables, and their causal relationships not only to the dependent variable, but to one another. In essence, one builds a model of how the system is predicted to work, and then tests the model with real data from the experiment. With SEM, we will answer questions about the response of key variables within the context of the whole system. For example, we can answer questions such as how soil type influences the degree to which fire and fire surrogates differ in the susceptibility of trees to bark beetles. Factors such as slope, elevation, aspect, and initial fuel loads can be evaluated in the context of a structural equation model.
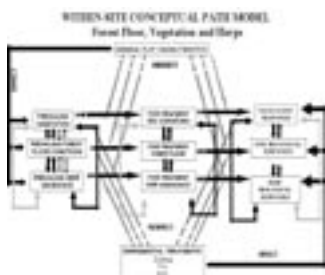
Network-level analyses will be the most challenging. Univariate methods will be useful for multi-site analyses for such things as determining the extent that alternative fuel reduction treatments influence plant diversity in relation to forest type across the NFFS network. Multivariate analyses at the network level will include meta-analysis, which has been used for decades in medical research. With this method, a researcher typically surveys the literature for studies on the variable in question, assembles a data set that describes response to some set of treatments on that variable, and then evaluates the commonality of response, or effect size, to treatment. The NFFS study has three design features that make it uniquely suitable for meta-analytic techniques: 1) each of the 13 sites can be regarded as a separate study; 2) each site has a robust 'stand-alone' experiment design; and 3) experimental designs are categorically identical among sites. With meta-analysis, we can ask not only to what extent forest types influence how plant species diversity is affected by alternative fuel reduction treatments, but also how a number of other variables affect diversity, including soil type, fuel loadings, season of burn, and logging technique. SEM can be used for multi-site analyses as well. A single structural model may be confirmed for one site, but not for another, leading the investigator to identify the factors responsible for the difference. These techniques can be very useful for understanding the conditional response to treatment of key variables, which will allow managers to better predict how fire and fire surrogate treatments will be likely to function in their own systems.

Installation of treatments for the NFFS is nearing completion at all 13 sites across the country. Publications describing single-site univariate studies are becoming numerous and are listed on the NFFS web site (http://www.fs.fed.us/ffs/). Single-site multivariate analyses are underway at some locations. Multiple site analyses have begun for vegetation, fuels, and wildlife. Results of interdisciplinary studies should become available in 2006.